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(71) Applicant *(for all designated States except US)*: TELIA AB [SE/SE]; S-123 86 Farsta (SE).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: ENGSTRÖM, Bo [SE/SE]; Blidvägen 189, S-976 32 Luleå (SE). LARSSON, Roger [SE/SE]; Docentvägen 53, S-951 64 Luleå (SE).

(74) Agent: KARLSSON, Berne; Telia Research AB, Koncernpatent, Rudsjöterrassen 2, S-136 80 Haninge (SE).

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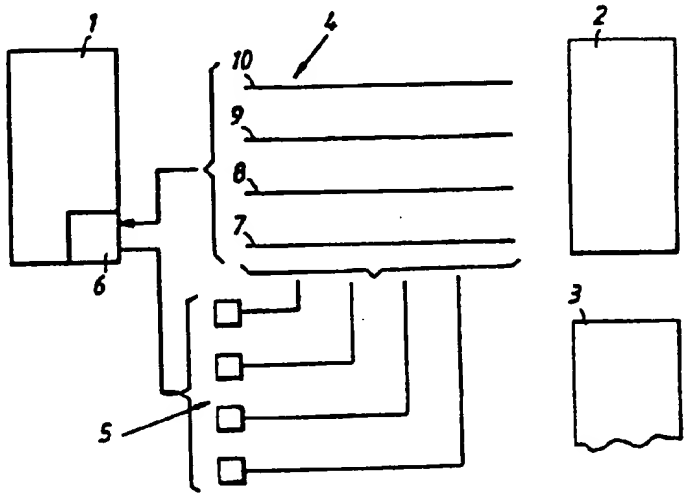

(57) Abstract

A multi-user system includes radio channels which are independent and uncorrelated for different users. The system operates with frequencies which, due to multi-path propagation, are more or less attenuated for one user and more or less amplified for another user. Elements (6, 6', 6'') are arranged to detect or measure the attenuation/amplification for the different frequencies. The elements also prevent signal or information transmission at frequencies which drop below a predetermined lowest attenuation by disconnecting the frequency or frequencies in question and connecting a corresponding number of frequencies which pass the attenuation value criterion.

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ARRANGEMENT IN A MULTI-USER SYSTEM

TECHNICAL FIELD

The present invention relates to an arrangement in a multi-user system comprising radio channels which are independent and uncorrelated for different users and in which frequencies, due to multi-path propagation, are more or less attenuated for one user and more or less amplified for another user.

PRIOR ART

There are time-dispersive radio channels in which signalling occurs in an environment which causes reflections with significant amplitude and long delays. In digital radio systems, a radio channel is usually designated as frequency-selective when the reflections have delays which are longer than the symbol length. By this is meant that different frequencies in the spectrum, of the signal are dispersed in different ways. In particular, it can be noticed that the different frequencies are attenuated by different amounts. The traditional methods for signalling in such an environment are, among others, different arrangements for achieving diversity, use of equalizers, use of a so-called RAKE receiver or suitable channel coding.

OFDM (Orthogonal Frequency Division Multiplex) is a form of modelling in which a broadband signal is multiplexed on many narrow-band channels, normally several hundred. The narrow-band channels can be packed very tightly since the fact is utilized, that the channels are orthogonal when the channel separation (Hz) is equal to 1/symbol length for rectangular symbols. OFDM is normally implemented with the aid of special circuits which carry out FFT (Fast Fourier Transform) very rapidly.

In OFDM signalling, channel coding is normally used for reducing error probability. OFDM combined with channel coding is called COFDM (Coded Orthogonal Frequency Division Multiplex). Systems which use this

form of signalling have in recent years been implemented for different types of broadcasting, that is to say one-way systems for digital radio broadcasting and for high-resolution digital TV. More recently, interest has also begun to be shown for utilizing the good characteristics of OFDM for two-way communication, for example in mobile systems, radio LANs and for point-to-multipoint applications.

In traditional OFDM systems, attempts are usually made to cope with the frequency-selective fading by coding out the errors which arise in the frequencies which are highly attenuated.

DESCRIPTION OF THE INVENTION

TECHNICAL PROBLEM

Quite generally there is a need to be able to eliminate the fading problem in a simpler manner than, for example, by coding methods. The invention intends to solve this problem, among others. In a system of this type, there is the requirement that it should be possible to hold the frequency attenuation above certain predetermined values for all users in the system. The invention also intends to solve this problem.

SOLUTION

That which can be mainly considered to be characterizing of an arrangement according to the invention is that elements are arranged to sense or measure the attenuation/amplification at the different frequencies and to prevent signal links or information transmission at frequencies which drop below a predetermined lowest permitted or stipulated attenuation.

In one embodiment of the concept of the invention, the multi-user system comprises both uplinks and downlinks. In the uplinks or outstations of a basestation, the said elements/basestation measure(s) the attenuation at the different frequencies or, respectively, the different outstations. On the basis of the

measurement made, the elements/basestation distribute(s) the frequencies at which the different outstations are to signal or send information. The multi-user system in the said embodiment can also include downlinks, that is to say basestation to outstations. Each of the latter outstations or said elements measures the attenuation for each frequency. The result of the measurement is signalled to the basestation/said elements which distribute(s) the frequency.

In a preferred embodiment, an OFDM system is utilized in which an identifiable data symbol for each carrier wave used can be easily extracted. When a respective identifiable data symbol appears, the possibility exists of obtaining attenuation by comparison of transmitted and received amplitudes. The said elements detect the said frequencies continuously or detect variation of a respective radio channel in the system at predetermined time intervals. In this manner, adaptive signal or information transmission coupled in and out is obtained as the frequency attenuation exceeds or respectively drops below the predetermined attenuation.

The arrangement also operates when a multiplexing function is in use which allows overlapping between the users. The said OFDM system is utilized for a number (small number) of users, for example four users, and operating with a substantially greater number of carrier waves, for example 128 carrier waves, whereby the element is arranged to carry out measurements and determinations of the attenuation value on all or, with optimization, a predetermined number of carrier waves.

According to the invention, there are also distinctive features regarding the operation of the element. The said element is to be arranged to search for the lowest amplitude among all carrier waves affected which at that time is not allocated to any user. The element is also to seek out all users in this connection. The element is furtheremore arranged to allocate the carrier wave thus found/taken out to a user to whom a sufficient number of carrier waves has not been allocated

on the occasion in question and also has most to gain by using the carrier wave found, whereby the selection criterion can be the highest amplitude in relation to the mean amplitude of the user. The element can repeat these functions until all users have been allocated as many carrier waves as are needed for the signal or information transmission in question. The element is also to repeat the said functions as often as is needed in order to follow the variations of the radio channel.

ADVANTAGES

Through that which has been proposed above, an effective signal and information transmission is achieved in the system. All users can obtain good quality in their radio channels. It can be mentioned in this connection that the mean power can be increased considerably for all users and an example of an increase of between 3-5 dB for all users can be achieved in spite of the fact that the attenuation can go down to minus 37 dB relative to the maximum power for certain frequencies. As an example it can be mentioned that carrier waves which are attenuated by more than minus 13 dB have not been used in the case specified here.

DESCRIPTION OF THE FIGURES

A presently proposed embodiment of an arrangement which exhibits the characteristics which are significant of the invention will be described in the text below, at the same time referring to the attached drawings, in which

Figure 1 shows an OFDM system with uplinks from outstations to the basestation and where frequencies are measured and distributed amongst users,

Figure 2 shows, in a basic form, downlinks from a basestation to an outstation where the frequencies are measured in a respective outstation and the result is signalled back to the base station which carries out the frequency distribution to

the users, and

Figure 3 shows, in a diagram form, frequency allocation for four users on 128 carrier waves where all users signal at 32 frequencies and where no overlap is allowed.

DETAILED EMBODIMENT

In Figure 1, a basestation is designated by 1 and outstations are represented by 2 and 3. There can be several outstations. The uplinks are basically designated by 4 and users by 5. The basestation is in this case provided with an element 6 which, in a manner known per se, is arranged to measure the attenuation at respective frequencies which have been symbolized by 7, 8, 9 and 10. Depending on the measurement, different frequencies are adaptively coupled in and out. In the case where the frequencies are attenuated and assume a lowest permitted attenuation, there is no information or signal transmission via the said frequency. Instead, another frequency is selected in accordance with the present invention. The users 5 are thus assured at any instant of an adequate number of frequencies with attenuations above the said permitted attenuation. The element senses the frequencies continuously or at certain intervals which are set in accordance with the radio channels in question and ensures good transmission. The coupling together of selected frequencies and users has been symbolized by a matrix form.

The said OFDM system can also include downlinks 7 between the basestation 1' and the outstations 2' or, respectively, 3' and so forth. The said elements are then arranged both at the base station and a respective outstation and have been given the designations 6' and, respectively, 6". The attenuation is measured by means of the element part at a respective outstation. The result of the measurement is transferred to the basestation, for example via a signal channel 8. The element part 6' thereafter carries out the distribution of approved frequencies to the different users 5' in a corresponding

manner to that above.

The OFDM system has advantages in connection with the said measuring function in that it naturally operates with a data symbol for each carrier wave used. The data symbol can be easily identified for the respective carrier wave and the attenuation can be obtained by comparing the received amplitude with the transmitted amplitude.

Figure 3 is intended to illustrate an embodiment example in which frequency allocation has been carried out in a large OFDM system for four users and altogether 128 carrier waves. All users signal at 32 frequencies. In the present case, a multiplexing method which allows overlapping between the users has not been utilized even though such an application is possible per se. The system operates with an algorithm for frequency allocation which is simple and which has not been optimized for minimizing the quantity of data which has to be signalled to the base station in a downlink. Neither has the measuring method been optimized but, instead, it is assumed that all frequencies are measured for all users. The algorithm guarantees that the most attenuated carrier waves are not used for signalling except in the rare cases where all radio channels are weak at the same frequency.

The said elements 6, 6' and 6" operate with the following algorithm:

1. Seek out the lowest amplitude among all unallocated carrier waves and all users.
2. Allocate the carrier wave found to the user who has not been allocated a sufficient number of carrier waves and who, moreover, has most to gain from using the carrier wave found, whereby the selection criterion can be the highest amplitude in relation to the mean amplitude of the user.
3. Repeat the above according to items 1 and 2 until users have obtained as many carrier waves are are needed.
4. Repeat the above according to items 1-3 as often as is needed for following the variation of the radio

channel.

Figure 3 shows the result for four users. In the upper part of the figure, the amplitudes of the four different radio channels are shown for different frequencies. The numbers in the top figure and dashes in the lower figure show which frequencies have been allocated to each user. The diagram according to Figure 3 shows that the frequencies which have been allocated largely have the same amplitudes which lie at a maximum for all the four radio channels. This situation naturally reflects optimum conditions. It is not always possible to achieve a maximum since each user is to be allocated a certain number of carrier waves. In the example, the mean power has increased between 3 and 5 decibels for all users. Even though there are attenuations at down to minus 37 dB relative to the maximum power, no carrier wave is used which is more attenuated than minus 13 dB.

The invention is not limited to the embodiment shown in the above as an example but can be subjected to modifications within the scope of the subsequent patent claims and the concept of the invention.

PATENT CLAIMS

1. User arrangement in a multi-user system comprising radio channels which are independent and uncorrelated for different users (5, 5') and in which frequencies 7, 8, 9, 10, due to multi-path propagation, are more or less attenuated for one user and more or less amplified for another user, and so forth, characterized in that elements (6, 6', 6") are arranged to detect or measure the attenuation/amplification at the different frequencies and to prevent signal or information transmission at frequencies which drop below a predetermined lowest permitted attenuation.

2. Arrangement according to Claim 1, characterized in that the multi-user system includes both uplinks and downlinks 4 and, respectively, 7, in that in the uplinks, that is to say from the outstations to a basestation (1), the said element 6/the basestation measures the attenuation for the different frequencies and distributes, depending on the measurements, the frequencies at which the different outstations are to signal or transmit information.

3. Arrangement according to Claim 1 or 2, characterized in that the multi-user system includes downlinks 7, that is to say from a basestation to outstations 2', 3', in that each of the last-mentioned outstations measures the attenuation at every frequency and in that the result of the measurement is signalled to the basestation 1'/said element 6' which distributes the frequencies amongst the users.

4. Arrangement according to any of the preceding claims, characterized in that the system in question is an OFDM system in which an identifiable data symbol for each carrier wave used can be extracted, in that on the appearance of a respective identifiable data symbol, the possibility exists for obtaining the attenuation by comparison of transmitted and received amplitudes.

5. Arrangement according to any of the preceding claims, characterized in that the element detects said

frequencies continuously, or at predetermined time intervals detects a respective radio channel variation in the system and in this manner adaptively couples frequencies in and out for signalling or respectively transmission of information as the frequency attenuation exceeds or, respectively, drops below predetermined attenuation values.

6. Arrangement according to any of the preceding claims, characterized in that it is activated even in the case where a multiplexing function is in use which allows overlapping between the users.

7. Arrangement according to any of the preceding claims, characterized in that it includes an OFDM system for a number of users, for example four users, and operates with a considerably greater number of carrier waves, for example 128 carrier waves, whereby the element is arranged to carry out measurements and determinations of attenuation values on all or, with optimization, a predetermined number of carrier waves.

8. Arrangement according to any of the preceding claims, characterized

a) in that the element is arranged to seek out the lowest amplitude among all affected carrier waves which at that time is not allocated to any user, and to seek out all users,

b) in that the element is arranged to allocate the carrier wave thus found/taken out to a user to whom a sufficient number of carrier waves has not been allocated and, moreover, has most to gain from using the carrier wave found, whereby the selection criterion can be the highest amplitude in relation to the mean amplitude of the user,

c) in that the element repeats the functions according to a and b until all users have received as many carrier waves as are needed, and

d) in that the element (6, 6', 6") repeats the functions according to a, b and c as often as is needed for following the variations of the radio channels.

9. Arrangement according to any of the preceding

claims, characterized in that allocated frequencies are given amplitudes which are essentially at a maximum for all the four radio channels.

10. Arrangement according to any of the preceding claims, characterized in that the users are allocated a predetermined number of frequencies which is the same for all users, in that the element (6, 6', 6") detects/ measures all the frequencies of the system continuously or at intervals which can be predetermined, and in that the element connects and disconnects frequencies to the users in dependence on the variation in the frequency attenuations.

AMENDED CLAIMS

[received by the International Bureau on 20 March 1995(20.03.95); original claims 1 and 4 amended; remaining claims unchanged (3 pages)]

1. User arrangement in a multi-user system comprising radio channels which are independent and uncorrelated for different users (5, 5') and in which frequencies 7, 8, 9, 10, due to multi-path propagation, are more or less attenuated for one user and more or less amplified for another user, and so forth, **characterized** in that the system is an orthogonal frequency division multiplex (OFDM) system having a data symbol for each carrier wave used and in that elements (6, 6', 6") are arranged to detect or measure the attenuation/amplification at the different carrier wave frequencies and to prevent signal or information transmission at frequencies which drop below a predetermined lowest permitted attenuation.

2. Arrangement according to claim 1, **characterized** in that the multi-user system includes both uplinks and downlinks 4 and 7 respectively, in that in the uplinks, that is to say from the outstations to a basestation (1), the said element 6/the basestation measures the attenuation for the different frequencies and distributes, depending on the measurements, the frequencies at which the different outstations are to signal or transmit information.

3. Arrangement according to claim 1 or 2, **characterized** in that the multi-user system includes downlinks 7, that is to say from a basestation to outstations 2', 3', in that each of the last-mentioned outstations measures the attenuation at every frequency and in that the result of the measurement is signalled to the basestation 1'/said element 6' which distributes the frequencies amongst the users.

4. Arrangement according to any of the preceding claims, **characterized** in that an identifiable data symbol for each carrier wave used can be extracted, in that on the appearance of a respective identifiable data symbol, the possibility exists for obtaining the attenuation by comparison of transmitted and received amplitudes.

5. Arrangement according to any of the preceding claims, **characterized** in that the element detects said frequencies continuously, or at predetermined time intervals detects a respective radio channel variation in the system and in this

manner adaptively couples frequencies in and out for signalling or respectively transmission of information as the frequency attenuation exceeds or, respectively, drops below predetermined attenuation values.

6. Arrangement according to any of the preceding claims, **characterized** in that it is activated even in the case where a multiplexing function is in use which allows overlapping between the users.

7. Arrangement according to any of the preceding claims, **characterized** in that it includes an OFDM system for a number of users, for example four users, and operates with a considerably greater number of carrier waves, for example 128 carrier waves, whereby the element is arranged to carry out measurements and determinations of attenuation values on all or, with optimization, a predetermined number of carrier waves.

8. Arrangement according to any of the preceding claims, **characterized**

a) in that the element is arranged to seek out the lowest amplitude among all affected carrier waves which at that time is not allocated to any user, and to seek out all users,

b) in that the element is arranged to allocate the carrier wave thus found/taken out to a user to whom a sufficient number of carrier waves has not been allocated and, moreover, has most to gain from using the carrier wave found, whereby the selection criterion can be the highest amplitude in relation to the mean amplitude of the user,

c) in that the element repeats the functions according to a and b until all users have received as many carrier waves as are needed, and

d) in that the element (6, 6', 6") repeats the functions according to a, b and c as often as is needed for following the variations of the radio channels.

9. Arrangement according to any of the preceding claims, **characterized** in that allocated frequencies are given amplitudes which are essentially at a maximum for all the four radio channels.

10. Arrangement according to any of the preceding claims, **characterized** in that the users are allocated a

predetermined number of frequencies which is the same for all users, in that the element (6, 6', 6") detects/measures all the frequencies of the system continuously or at intervals which can be predetermined, and in that the element connects and disconnects frequencies to the users in dependence on the variation in the frequency attenuations.

Fig. 1

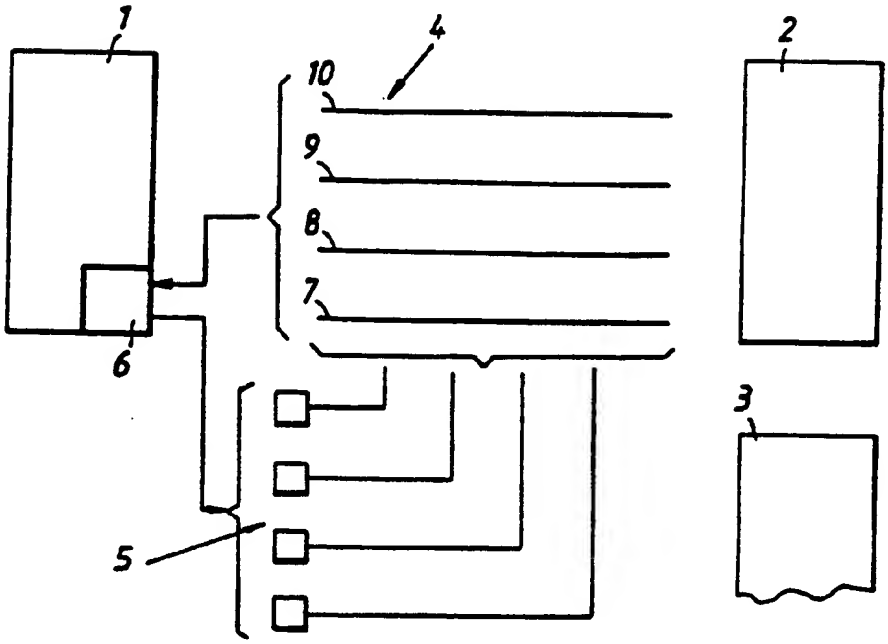
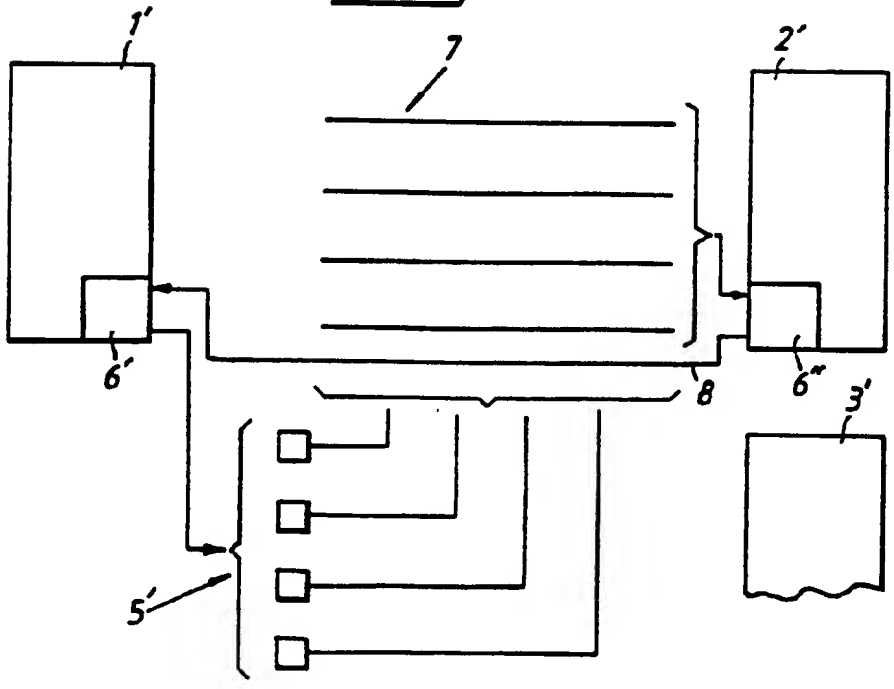
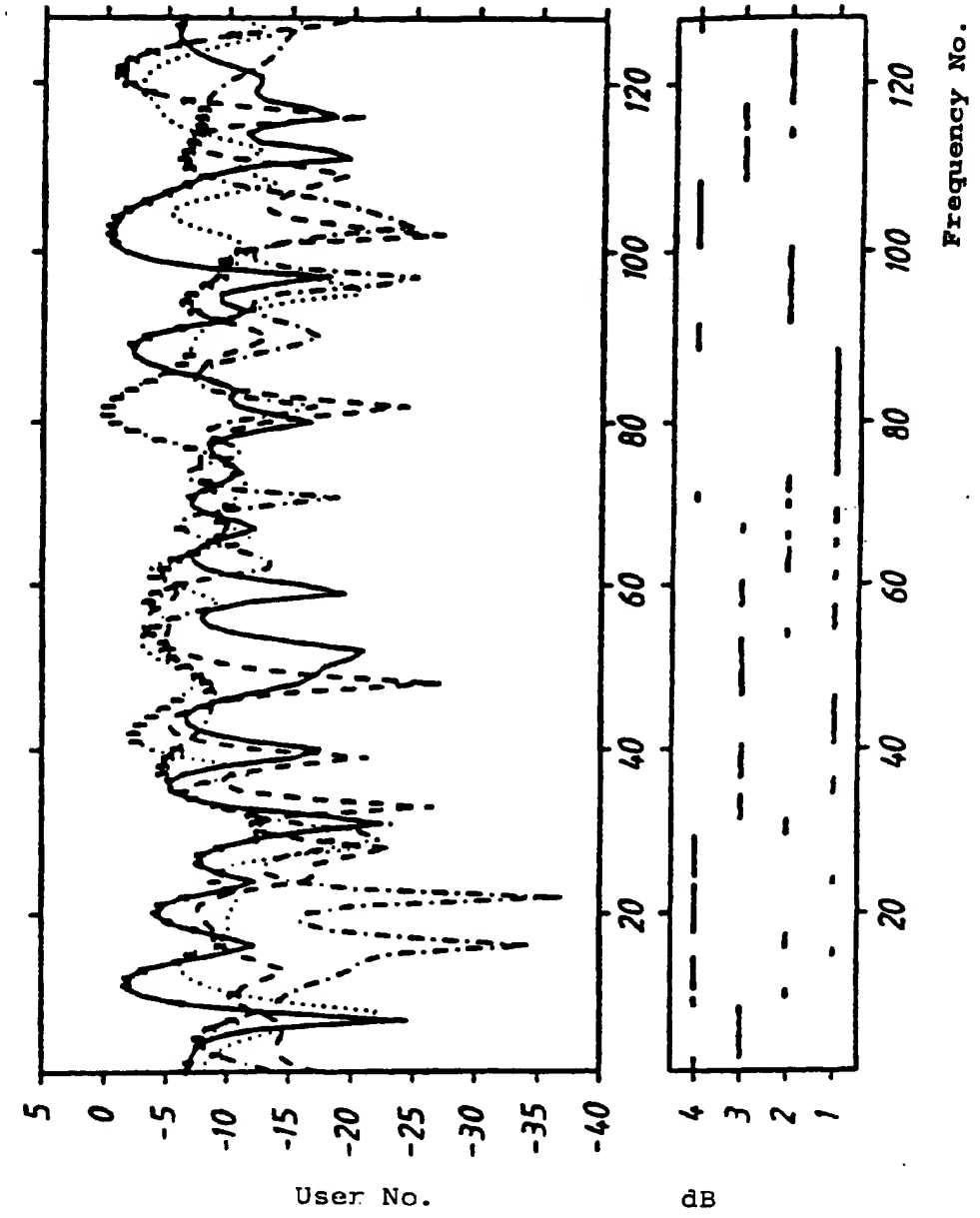


Fig. 2

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-30
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-40
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40
60
80
100
120
4
3
2
1
dB
Frequency No.

Fig.3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 94/00841

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04B 7/12, H04B 7/26
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	DE, A1, 3621679 (EUGEN BEYER, ELEKTROTECHNISCHE FABRIK GMBH & CO), 14 January 1988 (14.01.88), column 1, line 3 - line 15; column 1, line 54 - column 2, line 1, abstract	1
X	--	2-10
P,A	FR, A1, 610988 (LABORATOIRES D'ELECTRONIQUE PHILIPS), 17 August 1994 (17.08.94), column 2, line 15 - line 50, abstract	1
P,Y	--	2-10

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
17 February 1995	17 -02- 1995
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Elisabet Åselius Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 94/00841

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y		2-3,5-6,8-10
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INTERNATIONAL SEARCH REPORT

Information on patent family members

31/12/94

International application No.
PCT/SE 94/00841

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FR-A1- 610988	17/08/94	NONE	
US-A- 5203012	13/04/93	AU-A- 3661593	03/09/93
		CN-A- 1075389	18/08/93
		EP-A,A- 0626121	30/11/94
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